Gardens' Bulletin Singapore 58 (2) 2007: 155–178

Taxonomic notes on Asian species of Orthotrichaceae (Bryopsida): *Macromitrium* with gymnostomous capsules *

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Abstract

Nine taxa of the genus *Macromitrium* (Bryopsida, Orthotrichaceae) with gymnostomuous capsules in East Asia, including *Macromitrium benguetense* R.S. Williams, *M. brevituberculatum* Dix., *M. formosae* Card., *M. gymnostomum* Sull. & Lesq., *M. heterodictyon* Dix., *M. holomitrioides* Nog., *M. robinsonii* R.S. Williams, *M. schmidii* C. Muell., and *M. taiheizanense* Nog., are taxonomically revised. *Macromitrium robinsonii* and *M. brevituberculatum* are treated as new synonyms of *M. gymnostomum*, and *M. benguetense* as a new synonym of *M. schmidii.* Neotype was designated for *M. schmidii*, and types were selected for *M. heterodictyon*, *M. gymnostomum*, *M. brevituberculatum*, *M. taiheizanense*, and *M. formosae*. *Macromitrium schmidii* var. *macroperichaetialium* S.L. Guo & T. Cao was described as a new variety. A key to the seven accepted gymnostomous species of *Macromitrium* in East Asia is also given.

Introduction

Macromitrium is a rather large pantropical genus of mesophytic to xerophytic epiphytes, belonging to Orthotrichaceae, Bryopsida. It is distinguished by the creeping, prostrate stems giving rise to branches terminated by a sporophyte, the often contorted leaves twisted around the branches, and with mostly bulging, conic, papillose, or tuberculate leaf cells. Calyptrae are large, mitrate, plicate, naked or hairy. The ovate to cylindric capsules mostly have peristomes, which are at times reduced and fused to a low, single exostomial membrane.

Though Asia is rich in the species of *Macromitrium,* with about 85-90 species recorded (Crosby *et al.*, 1999; Eddy, 1996; Gangulee, 1976; Noguchi, 1967, 1972, 1989; O'Shea, 2002; Redfearn *et al.*, 1996; Tan and Iwatsuki, 1991, 1993), little taxonomic revision has been done except for those in Japan (Noguchi, 1989), Malaysia, Philippine and Indonesia (Eddy, 1996), Eastern India and its adjacent regions (Gangulee, 1976), and Papua New Guinea (Vitt, 1995).

There is a rather special group of *Macromitrium* with gymnostomous capsules, including *M. benguetense* R.S. Williams, *M. brevituberculatum* Dix., *M. formosae* Card., *M. gymnostomum* Sull. & Lesq., *M. heterodictyon* Dix., *M. holomitrioides* Nog., *M. robinsonii* R.S. Williams, *M. schmidii* C. Muell., and *M. taiheizanense* Nog. Since these species were published, there has been little taxonomic information about them, except for *M. gymnostomum* and *M. holomitrioides* (Crosby *et al.*, 1999).

During our taxonomic revision on Asian *Macromitrium*, we found a specimen with gymnostomous capsules marked as "China, Kwangtung: Ngok Shing Shan, Y. M. Taam 402C " in NY, which is rather similar to *M. schmidii* Muell. A further check on this specimen showed that it differs from the later by its rather long inner perichaetial leaves and its gymnostomous capsule that are constricted below the mouth into 4-angles or 4-furrows when dry. This specimen represents a hitherto undescribed taxon, here we placed it at the variety level and named it as *Macromitrium schmidii* var. *macroperichaetialium.* Our further study of the types showed that *M. brevituberculatum* and *M. robinsonii* are two new synonyms of *M. gymnostomum*, and *M. benguetense* is a new synonym of *M. schmidii.* In order to understand these gymnostomous species better and to stabilize the usage of the species epithet, a neotype was designated for *M. schmidii* C. Muell. and types were selected for *M. heterodictyon* Dix., *M. gymnostomum*, *M. brevituberculatum*, *M. taiheizanense* and *M. formosae*, and a key to these gymnostomous species was also given.

Taxonomic treatment

Macromitrium schmidii C. Muell., Bot. Zeit. 11: 61. 1853. Figs. 1-3.
Type: India, Nilgherri, leg. *Perrottet no. 22* (neotype, H-BR 2595002!, designated here) – *Macromitrium benguetense* R.S. Williams, Bull. New York Bot. Gard. 8: 343, 1914. *syn. nov.* **Type**: "Philippine, Baguio, on tree, 1570 meters, Oct. 1904, *Williams 830* (isotype, H-BR 2572023!).

Plants moderate-sized, forming yellowish-brown mats, darkish below. **Stems** creeping, up to 10 cm long, with erect branches, branches 10–20 mm high and 1.5–2 mm wide. **Branch leaves** moderately crisped and somewhat twisted when dry, widely spreading when moist, entire, lanceolate, (2.5) 3.5–4 mm long, 0.5–0.7 mm wide, the apex acuminate, somewhat incurved, keeled, plicate below; margins entire, plane on one side, reflexed-recurved on the other side, particularly in lower portion; costa single, prominent, ending a few cells below the apex or in the apex; laminal cells unistratose from top to base, upper laminal cells subquadrate-rounded to rounded-quadrate, 10–14 μm wide, obscure, densely pluri-papillose; median laminal cells rounded-quadrate or slightly elongate, 10–15 μm wide, 15–20 μm long, with a single, large conical papilla or 3–4 small papillae per cell; basal laminal cells brown-yellowish, rectangular to sublinear, 30–50 μm long, 6–10 μm wide, strongly thick-walled and sinuous, tuberculate to bulging-papillose.

Sporophytes lateral on branches; inner **perichaetial leaves** ovate-oblong, long-acuminate in upper part, 2.8–3.2 mm long, shorter than branch leaves, the costa ending far below the apex. Setae 4–6 mm, smooth, twisted to right. **Capsules** oblong-cylindric or oblong, 1–2 mm long, 0.6-0.8 mm wide, brown, plicate or ribbed under the mouth when dry, peristome absent. **Spores** 25–35 μm in diameter. **Calyptrae** moderate sized, 2–2.5 mm long, campanulate, with brownish hairs.

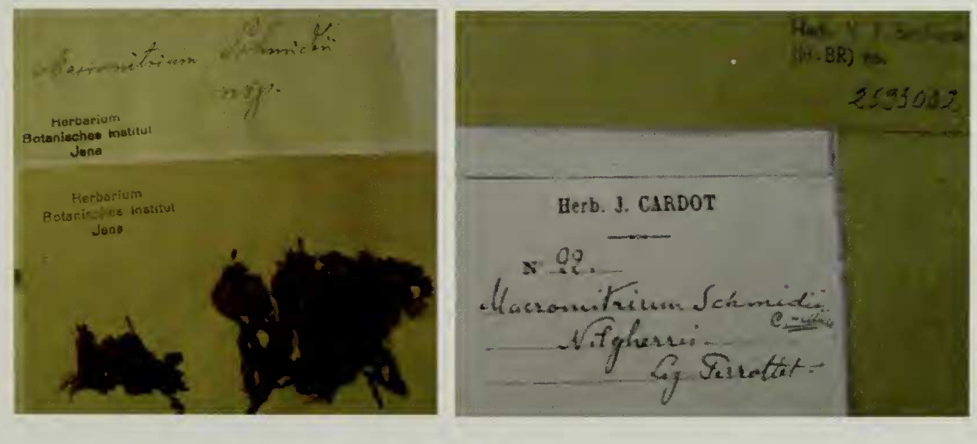


Fig. 1. Neotype and habit of *M. schmidii*: “Nilgherri, Leg. *Perrottet 22*” at H-BR.

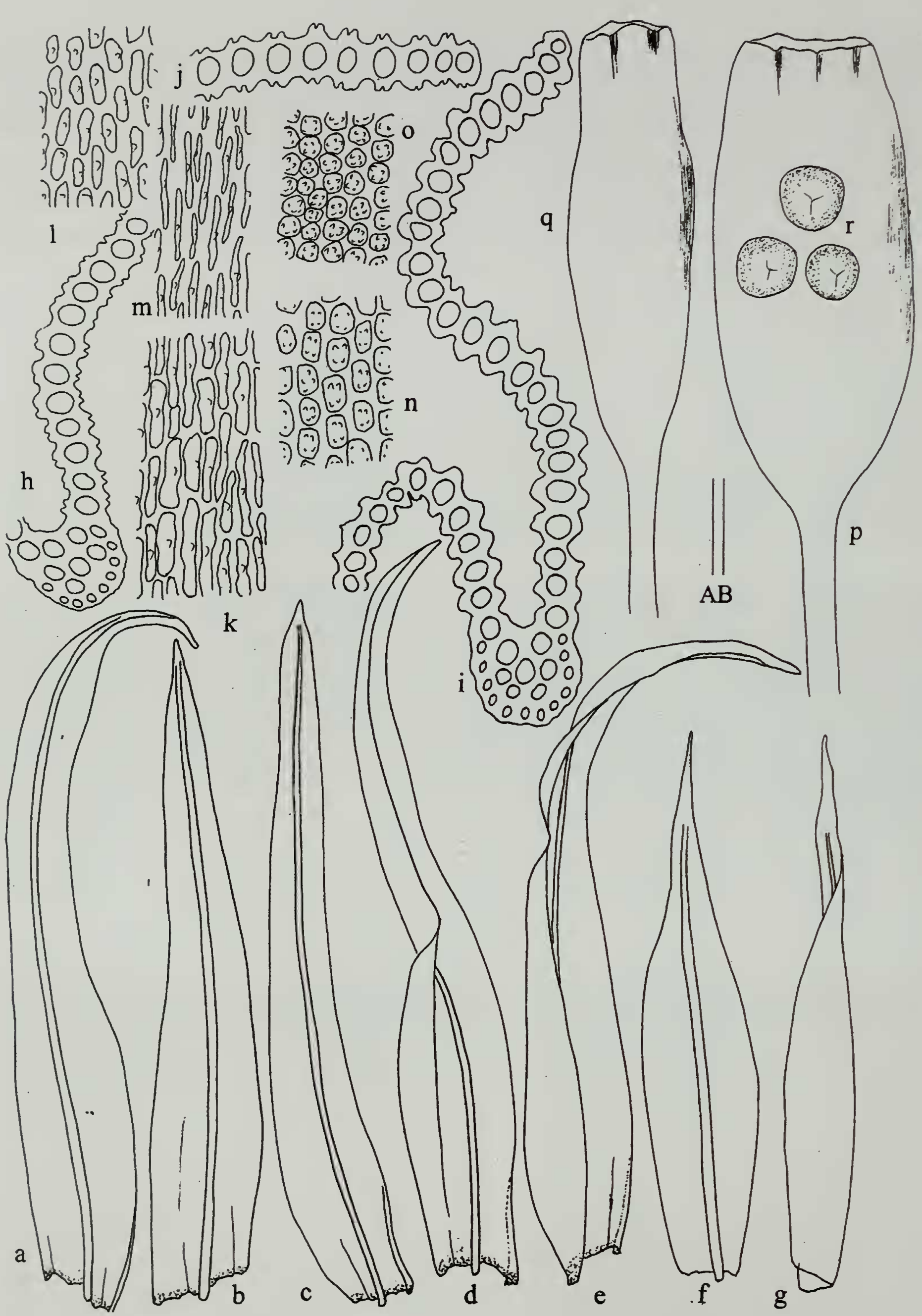


Fig. 2. *M. schmidii* C. Muell. a-e. Branch leaves; f-g. Perichaetial leaves; h. Transverse section of the meddle part of leaf; i. Transverse section of the basal part of leaf; j. Transverse section of the upper part of leaf; k, m. Basal laminal cells; l. lower laminal cells; n. Middle laminal cells; o. Upper laminal cells p–q. Capsules; r. Spores. All from the lectotype of *M. schmidii* at H-BR. Line scales: A = 0.5 mm (a-g, p-q); B = 50 µm (h-o, r).

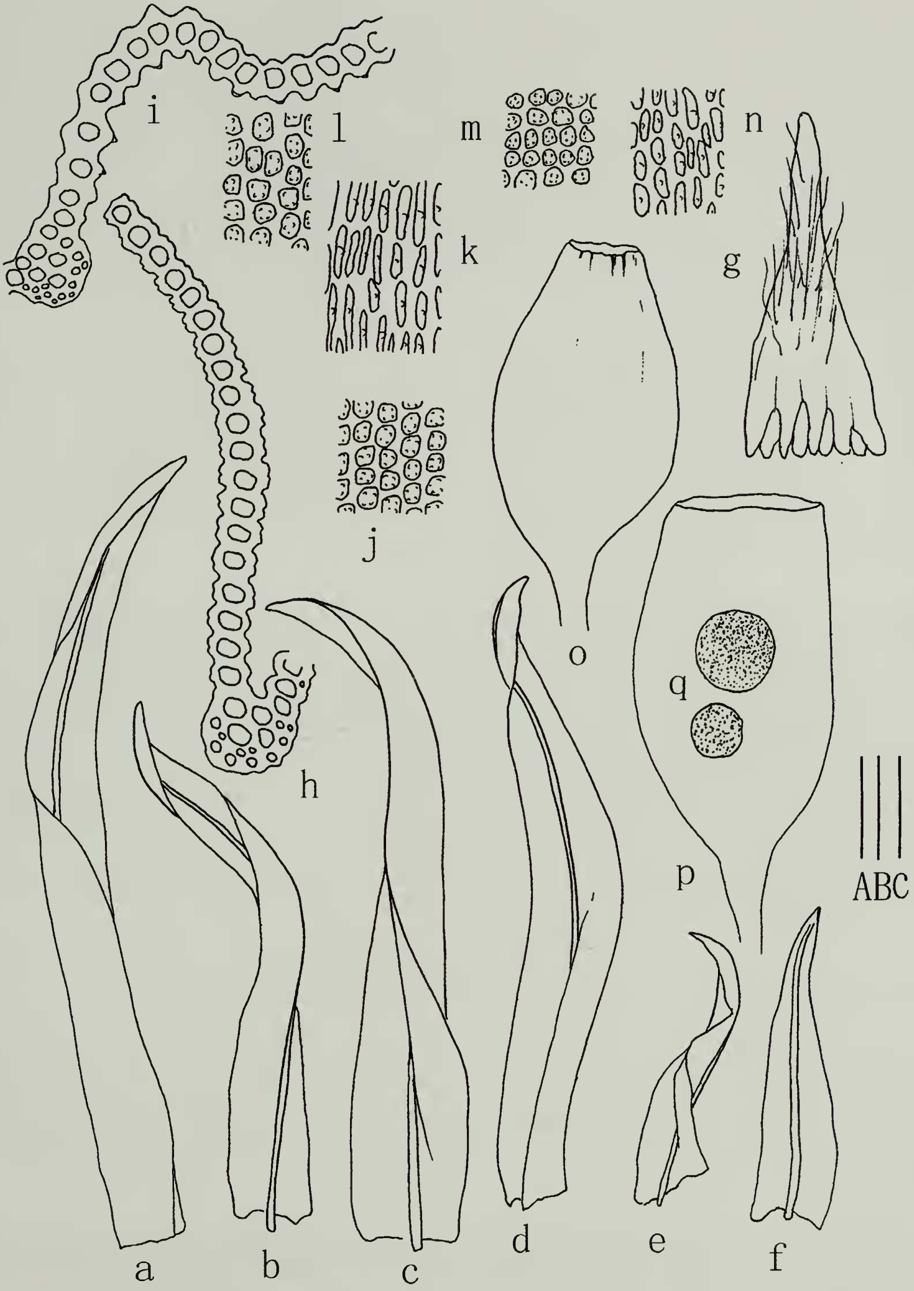


Fig. 3. *M. schmidii* C. Muell. a-d. Branch leaves; e-f. Stem leaves; g. Calyptra; h. Transverse section of the meddle part of leaf; i. Transverse section of the basal part of leaf; j. Upper laminal cells of branch leaf; l. Middle laminal cells of branch leaf; k. Basal laminal cells of branch leaf; m. Upper laminal cells of stem leaf; n. lower laminal cells of stem leaf; o. Dry capsule; p. Wet capsule; q. Spores. All from isotype of *M. benguetense* at H-BR. Line scales: A = 0.5 mm (a-d, f, o,p); B = 50 μm (g-m, q); C = 1 mm (g).

There has been no more taxonomic information of *M. schmidii* after it was published (Crosby *et al.*, 1999), and no citation about the type of the species could be found in the original publication by Mueller (1853). According to the title of the publication and context, we surmised that Mueller's original description on *M. schmidii* was based on the collection by Perrottet from Neigherri, South India. There were two specimens collected by Perrottet from Neigherri in H-BR, identified as *M. schmidii* by Mueller himself. We selected the specimen marked with "Neigherri, *Perrottet no. 22*" as the neotype (Fig. 1).

M. benguetense was described by R.S. Williams from Baguio of the Philippine in 1914. The type of *M. benguetense* and *M. schmidii* are rather similar except that the capsules of *M. benguetense* are broadly oval with small mouths, and its calyptrae are sparsely hairy, while the capsules of *M. schmidii* are oblong cylindric, and its calyptrae are densely hairy. Here we treated *M. benguetense* as a new synonym of *M. schmidii.*

Based on the type and other specimens of *M. schmidii*, the diagnostic features of *M. schmidii* are: 1) moderate-sized plants with lanceolate branch leaves; 2) upper laminal cells obscure, densely pluri-papillose; median laminal cells rounded-quadrate or subrectangular, bulging or with a single, large conical papilla, or 3–4 low papillae per cell; 3) inner perichaetial leaves ovate-oblong, long-acuminate in upper part, shorter than branch leaves; 4) the laminal cells of the inner perichaetial leaves elongate to linear-elongate from base to top, sinuous, thick-walled, with a single conical papilla; 5) capsules oblong-cylindric or oblong, peristome none, plicate under the mouth.

Distribution: India, Sri Lanka, Philippine, Vietnam (Tan & Iwatsuki, 1993).

Other specimens examined: **INDIA:** Nilgherri, *Perrottet* (H-BR 2595001); Madras, Madura, *G.. Foreau* 1925 (H); Nilghiri, *Suthi B. 7331* (H-BR 2595003). **SRI LANKA**: *Wichura 2744* (H-BR 2595004); Mire Bamforih (H-BR 2595006); ibid, *C. Mueller 41* (H-BR 2595005); Kalak, *T.W.N. Beckett c 29/2.*(H-BR 2595007).

Macromitrium schmidii var. macroperichaetialium S.L. Guo & Cao T., *var. nov.* (Figs. 4-6)

Macromitrium schmidii Muell. satis similes, sed differt foliis perichaetialibus ad 5.5 mm longis, excedenibus foliis vegetatiis. **Type**: China, Kwangtung: Ngok Shing Shan, Sai-lin-shan Village, Sin-fung district; thicket on steep slope. 23-31 March 1938, *Y. M. Taam 402C* (holotype, NY!).

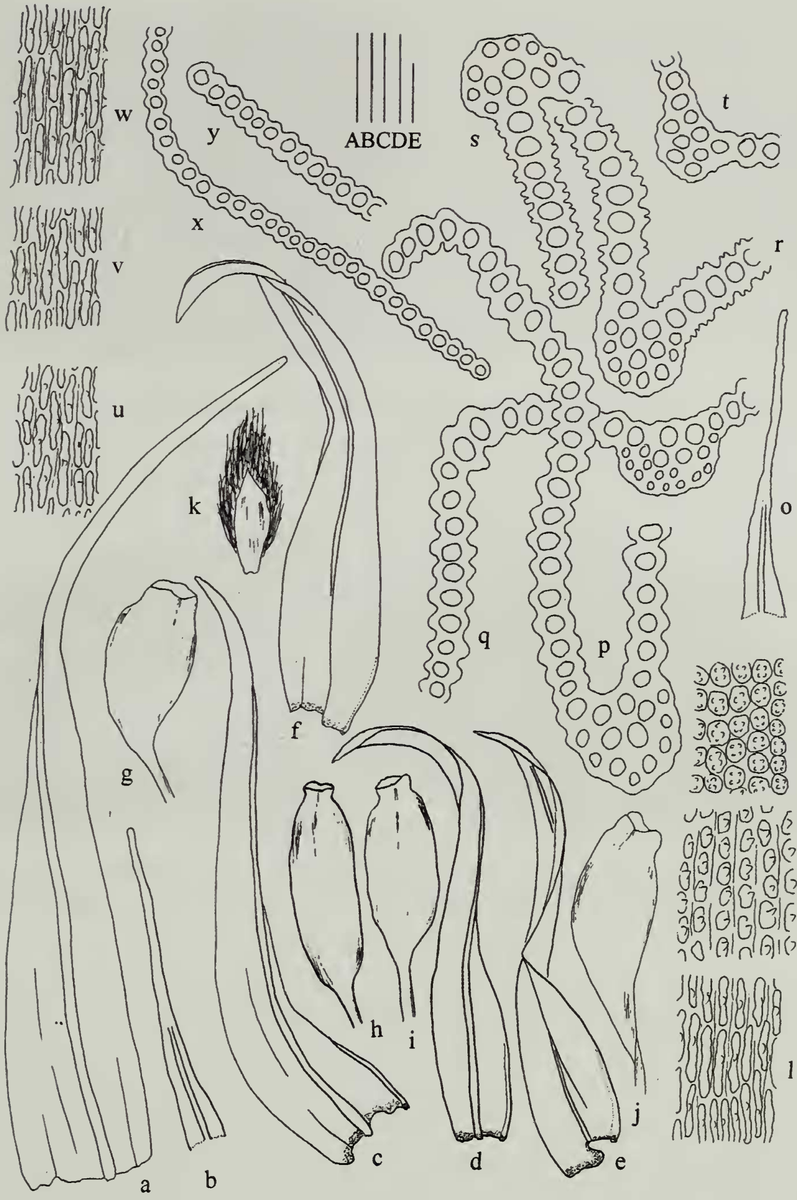
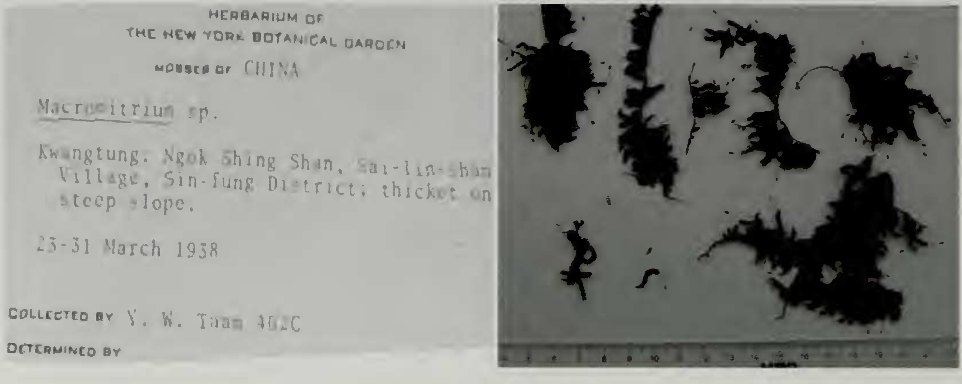


Fig. 4 *Macromitrium schmidii* var. *macroperichaetialium*. a. Perichaetial leaf; b, o. upper part of perichaetial leaf, c-f. branch leaves; g-j. dry capsules; k. calyptra; l. basal laminal cells of branch leaf; m. middle laminal cells of branch leaf; n. upper laminal cells of branch leaf; p. transverse section of the middle part of branch leaf; q. transverse section of the basal part of branch leaf; r, s. transverse section of the upper part of branch leaf; t, y. transverse section of the upper part of perichaetial leaf; u. upper laminal cells of perichaetial leaf; v. middle laminal cells of perichaetial leaf; w. basal laminal cells of perichaetial leaf; x. transverse section of the middle part of perichaetial leaf. All from holotype at NY. Line scales: A = 0.5 mm (a, c-f); B = 50 µm (l-n, p-y); C = 2 mm (k); D= 1 mm (b, o); E= 0.5 mm (g-j).



HERBARIUM OF
THE NEW YORK BOTANICAL GARDEN
MOSSES OF CHINA

Macromitrium sp.

Kwangtung: Ngok Shing Shan, Sai-lin-shan Village, Sin-fung District; thicket on steep slope.

23-31 March 1938

COLLECTED BY Y. W. Taam [illegible]
DETERMINED BY

Fig. 5. Holotype and habit of *M. schmidii* var. *macroperichaetialium* in NY.

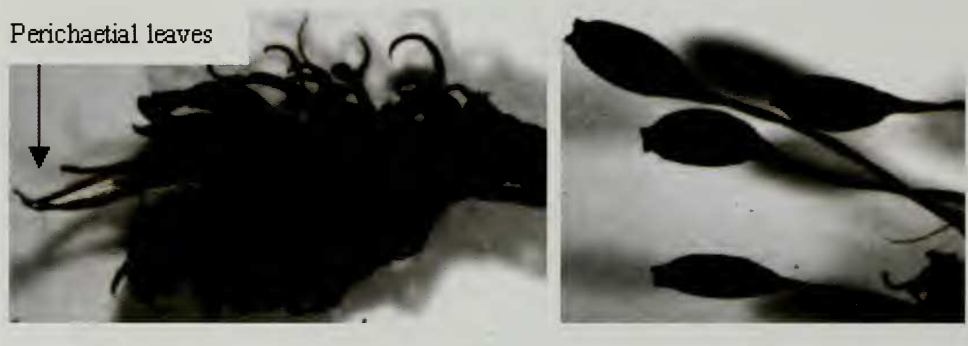


Fig. 6. *M. schmidii* var. *macroperichaetialium* showing the perichaetial leaves and the gymnostomous capsules constricted below the mouth in a 4-angled or 4 –furrowed shape.

Plants moderate-sized, forming yellowish-brown mats, darkish below. **Stems** creeping, up to 10 cm long, with erect branches, branches 10–15 mm high and 1–2 mm wide. **Branch leaves** moderately crisped and somewhat twisted when dry, widely spreading when moist, entire, lanceolate, (2.5) 2.7–3.5 mm long, 0.4–0.6 mm wide, the apex acuminate, somewhat incurved, keeled, slightly plicate below; margins entire, plane on one side, reflexed-recurved on the other, particularly in lower portion; costa single, prominent, ending below the apex or in the apex; laminal cells unistratose from top to base; upper laminal cells subquadrate-rounded to rounded-quadrate, 9–12 μm wide, obscure, pluri-papillose; median laminal cells rounded-quadrate or slightly elongate, thick-walled, 10–11 μm wide, 13–14 μm long, with a single, large conical papilla or pluripapillae; basal laminal cells rectangular to sublinear, 22–30 μm long, 6-8 μm wide, strongly thick-walled and sinuous, often with a single large papilla per cell.

Sporophytes lateral on branches. **Inner perichaetial leaves** lanceolate, gradually long-acuminate in upper part, up to 5.5 mm long, much longer than branch leaves; costa long excurrent, slightly coarse in the upper part; the laminal cells of the perichaetial leaves elongate to linear elongate from base to top, sinuous, thick-walled, with a single conical papilla per cell; Paraphyses numerous. Setae (4) 6–7 mm, smooth, twisted to right. **Capsules** oblong-cylindric or oblong, 1.3–1.5 mm long, 0.5–0.65 mm wide, brown, constricted below the mouth in 4-angled or 4-furrowed shape, peristome absent. Spores not seen. **Calyptrae** large, cucullate, 2.0–2.5 mm long, with many long, flexuose or stiff, brown-yellowish hairs.

The specimen marked as "China, Kwangtung: Ngok Shing Shan, Y. M. Taam 402C (NY) " shares the following characteristics with the neotype of *M. schmidii* at H-BR: 1) moderate-sized plants, with lanceolate branch leaves; 2) upper and median laminal cells subquadrate-rounded to rounded-quadrate, obscure, pluripapillose; basal laminal cells rectangular to sublinear, strongly thick-walled and sinuous, often with a single large papilla per cell; 3) the laminal cells of the inner perichaetial leaves elongate to linear-elongate from base to top, sinuous, thick-walled, with a single conical papillae; 4) gymnostomous capsules. However, the inner perichaetial leaves of the specimen (*Taam 402C*, NY) are long lanceolate, gradually long-acuminate in upper part, much longer than branch leaves, its capsules distinctly constricted below the mouth in a 4-angled or 4-furrowed shape, while the inner perichaetial leaves of *M. schmidii* are similar to its branch leaves, and its capsule only plicate or ribbed without a constriction under the mouth in a 4-angled or 4-furrowed shape. We consider that the specimen represents a hitherto undescribed taxon, here we placed it at variety level and named it as *Macromitrium schmidii* var. *macroperichaetialium* based on its longer inner perichaetial leaves. *Distribution*: China.

Macromitrium heterodictyon Dix., Hong Kong Naturalist, Suppl. 2: 12. 6. 1933. (Fig. 7). **Type**: China, Hong Kong, granite rock, 100-200 ft. alt., Amoy I, 11 Jul 1931, coll. *Herklots* (*B.17 E*) (holotype, BM!); Hongkong, coll. *Ah Nin (B. 21E)*, 12 Jul 1931 (paratype, BM!); Hongkong, granite rock, 1,000-1,500 ft. alt., Shaukiwan, coll. *Ah Nin (H. 4I)*, 5 Oct 1931 (paratype, BM!); Hongkong, Lan Yau Peak, Lan Tau Is., coll. *Herklots 359* (paratype, BM!).

Plants small to moderate-sized, forming yellowish-brown mats. **Stems** creeping, up to 4 cm long, with erect branches, branches 5–6 mm high and 1–1.3 mm wide. **Branch leaves** strongly crisped when dry, widely spreading when moist, entire, long lingulate or lanceolate, 2.5-3 mm long, 0.4–0.5 mm wide; the apex acute or acuminate, somewhat incurved, keeled, slightly plicate below; margins entire, usually plane on one side and recurved on the other; costa single, prominent, ending below the apex or rarely in the apex, smooth; laminal cells unistratose, clear and smooth from top to base, moderate thick-walled; upper and median laminal cells small and clear, in diagonal rows, subquadrate-rounded to rounded-quadrate, 5–7 μm wide, gradually elongate from lower part to base. Basal laminal cells along costa rectangular, thin-walled, 7.5–12.5 μm wide, 20–30 μm long, looking like "calymperoid" cells, those near margins elongate, rectangular to sublinear, 17.5–42 μm long, 5–10 μm wide, thick-walled and slightly sinuous.

Sporophytes lateral on branches. **Inner perichaetial leaves** similar to branch leaves, ovate-oblong, acuminate, 2.5–3 mm long, 0.5–0.6 mm wide; costa smooth, ending below the apex; laminal cells quadrate or subquadrate, smooth and clear. Paraphyses numerous. Setae 2–3 mm, smooth, twisted to right. **Capsules** oblong-cylindric or oblong, 1.6–2 mm long, 0.6–0.9 mm wide, brown, constricted or slightly constricted below the mouth in 4-angled or 4 –furrowed shape, peristome absent. **Calyptrae** rather large, campanulate, 2.5–3 mm long, with many long, brown-yellowish hairs. Spores not seen.

M. heterodictyon is somewhat similar to *M. schmidii*, but differs from the latter by its smooth and clear laminal cells from leaf top to base, and the capsules constricted below the mouth in a 4-angled or 4-furrowed shape. It is also similar to *M. schmidii* var. *macroperichaetialium* in their plant and capsule shape, but the new variety could be distinguished from *M. heterodictyon* by its pluripapillose laminal cells and its longer inner perichaetials leaves with gradually long-acuminate upper part.

In Dixon's original publication of *M. heterodictyon,* he considered the species similar to *M. japonicum*, only differed from the latter by its gymnostomous capsules. Our check on the types of *M. heterodictyon* shows that *M. heterodictyon* is distinctly different from *M. japonicum* by its clear and smooth laminal cells without any papillae, while the upper and median laminal cells of *M. japonicum* are obscure and densely pluripapillose.

M. heterodictyon Dix. is a distinct species, its diagnostic features are: 1) plants small to moderate-sized, branches short, less than 6 mm high; 2) laminal cells smooth and clear from top to base, median and upper laminal cells in diagonal rows, moderately thick-walled, basal laminal cells along costa rectangular, thin-walled, "calymperoid" in areolation; 3) inner perichaetial leaves ovate-oblong, acuminate, similar to branch leaves in length; 4) oblong-cylindrical to oblong gymnostomous capsules, constricted below the

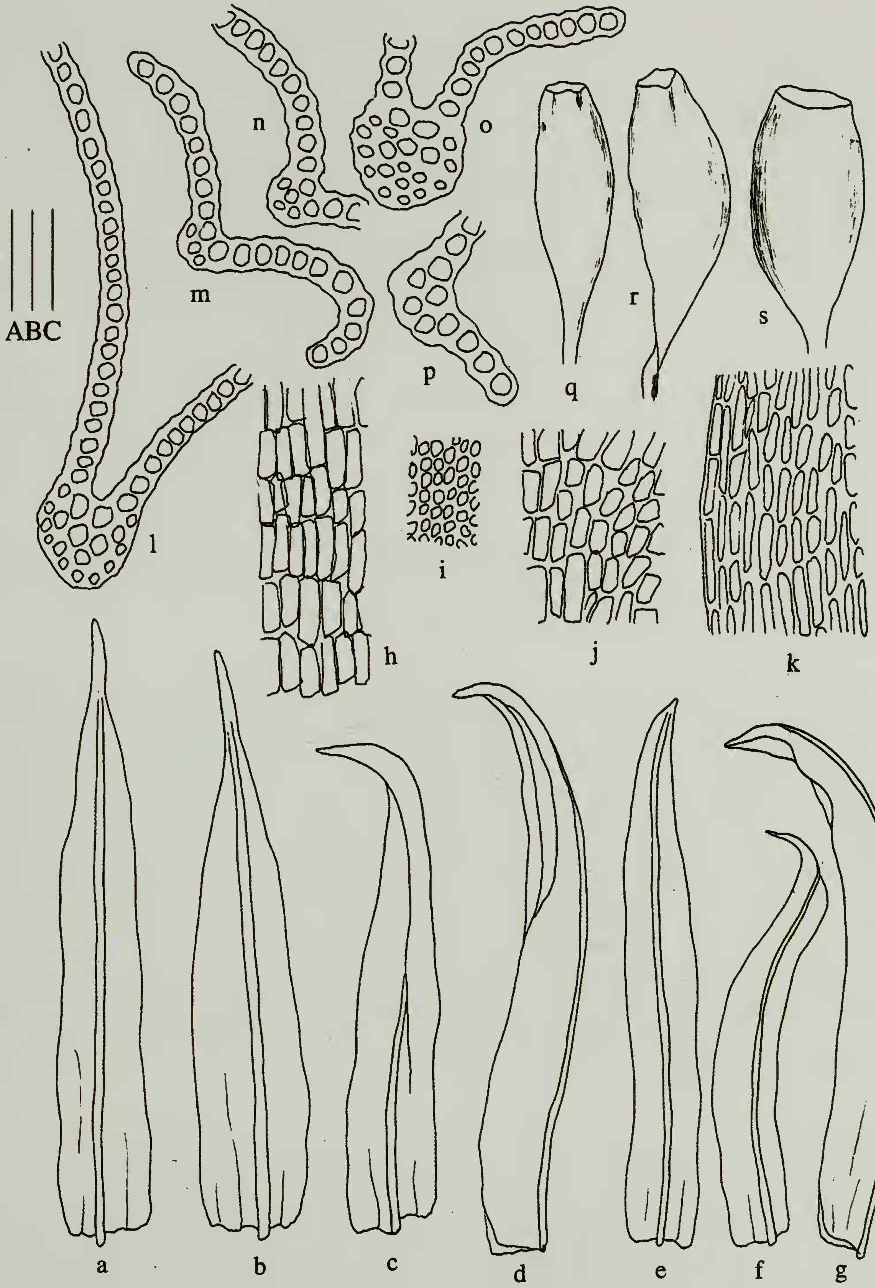


Fig. 7. *Macromitrium heterodictyon* Dix. a-b. Perichaetial leaves; c-g. Branch leaves; h. Basal lamina cells near costa; i. Upper laminal cells; j. Lower laminal cells; k. Basal laminal cells near margins; l. Transverse section of the basal part of leaf; m-o. Transverse section of the middle part of leaf; p. Transverse section of the upper part of leaf; q-r. Dry capsules; s. Wet capsule. All from holotype of *M. heterodictyon* at BM. Line scales: A = 0.5 mm (a-g); B = 50 µm (h-p); C= 0.8 mm (q-s).

mouth in a 4-angled or 4 –furrowed shape; and 5) calyptrae rather large, campanulate, up to 3 mm long, with many long, brown-yellowish hairs.

Distribution: China.

Macromitrium gymnostomum Sull. & Lesq., Proc. Am. Ac. Arts Sc. 4: 278. 1859. (Figs. 8–10)
Type: Japan, Shizuoka Pref., Simoda, *Wright* (lectotype selected by Noguchi, 1967, FH, not seen; isolectotype, NY00512839!); Japan, Ousima, one of the northern Loo Choo Islands (syntype, NY00512840!).
Macromitrium brevituberculatum Dix., Hong Kong Naturalist, Suppl. 2: 14. 5. 1933. *syn. nov.* **Type**: "Granite rock, 1,000-1,500 ft. alt., Shaukiwan, Hong Kong Is, 5 Oct 1931, coll. *Ah Nin* (*H.8*)."(holotype, BM 000576135!); "near sea level, Stanley, Hong Kong, 14 May 1931, coll. *Ah Nin (H. 43A*)" (Paratype, BM 000576134!).
Macromitrium robinsonii R.S. Williams, Bull., New York Bot. Gard. 8: 344, 1914, *syn. nov.* **Type**: "Philippines, Upper Lamao River, on tree, 1000 meters, Jan 1904, *Williams 1760*" (isotype, H-BR 2617006!)

Plants small to medium-sized, in dense, dark or reddish-brown mats, younger parts dark-greenish. **Stems** elongate, sparsely leaved, densely covered with reddish rhizoids; branches erect, up to 5 mm long, simple, or with several short branchlets. **Branch leaves** crisped when dry, widely spreading when moist, linear or linear-lanceolate, 1–2.5 × 0.15–0.2 mm; keeled, apex obtuse acute, acute or acuminate, lower half of leaves yellowish and hyaline, upper half rather obscure, leaf margins sometimes slightly recurved; costa yellowish-brown, reaching or almost reaching to the apex; laminal cells unistratose from top to base; median and upper laminal cells rather obscure, rounded or rounded-hexagonal, 4–5 µm, thin-walled, densely pluri-papillose; lower cells longer, rectangular, with or without papillae, basal cells linear, 8–25 µm long, with thickened walls, smooth.

Sporophytes lateral on branches. Inner perichaetial leaves ovate-lanceolate, acuminate, costa extending to leaf apex; laminal cells hyaline, smooth. Paraphyses numerous, slightly exserted beyond leaves. **Setae** brown, smooth, usually 5–8 mm long. **Capsules** obloid-cylindric, brown, deeply plicate, constricted at mouth when dry, peristome absent; operculum conic-subulate. **Spores** finely papillose, 20–25 µm diameter. **Calyptrae** cucullate, 1.7–2 mm long, somewhat lobed and plicate, naked.

M. brevituberculatum was described by Dixon in 1933 based on the

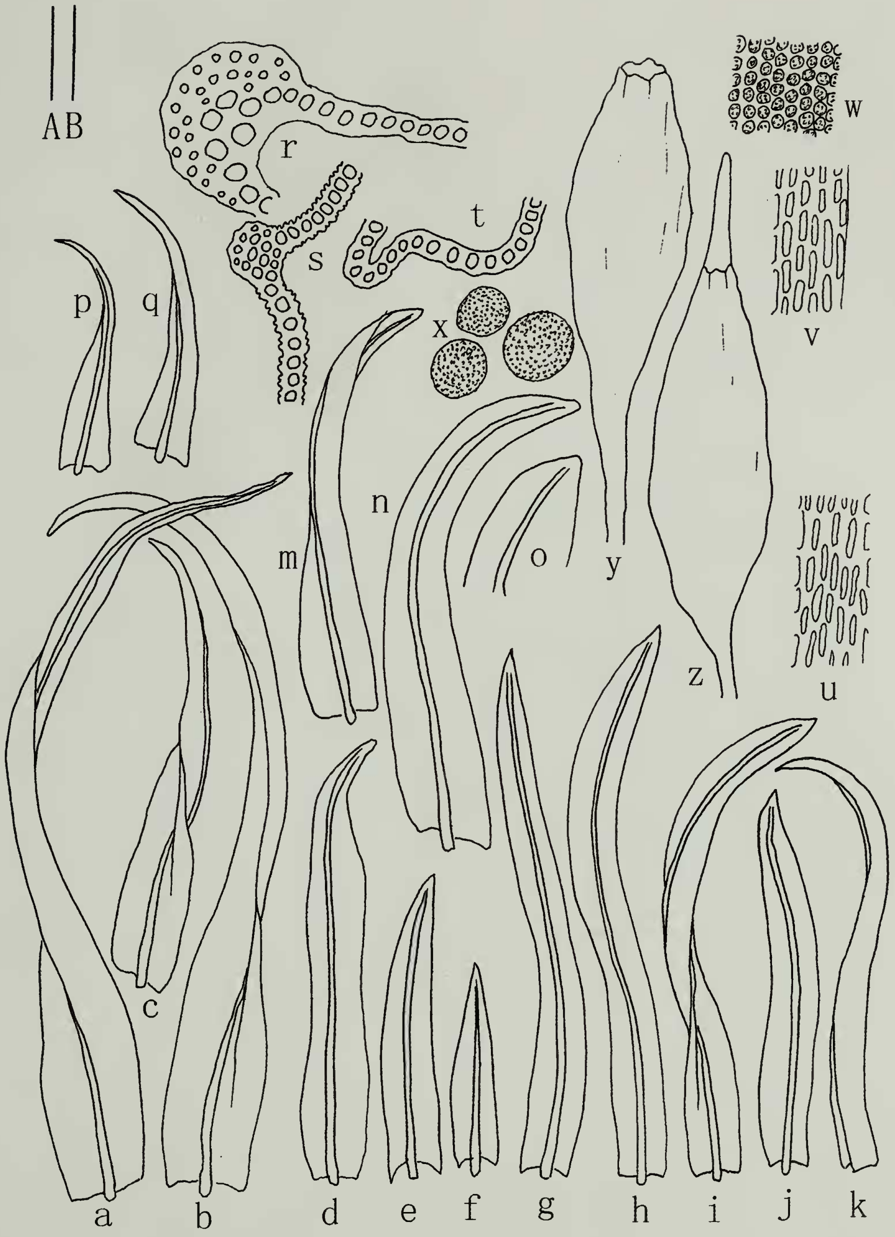


Fig. 8. *M. gymnostomum*. a-d, g-n. Branch leaves; o. Apex of branch leaf; p-q. Stem leaves; r, t. Basal transverse section of leaf; s. Upper transverse section of leaf; u. Basal laminal cells; v. Basal laminal cells near margins; w. Upper laminal cells; x. Spores; y-z. Capsules. (a-c, p-r,x from Hongkong, *Merrill 11159*, marked as "*M. gymnostomoides* Broth."; e-k, s-w, y-z, from isolectotype of *M. gymnostomum*; m-o from Japan, *Ferrie*, marked as "*M. subgymnostomum* Ther.). Line scales: A = 0.5 mm (a-n, p-q, y-z); B = 50 μm (r-x).

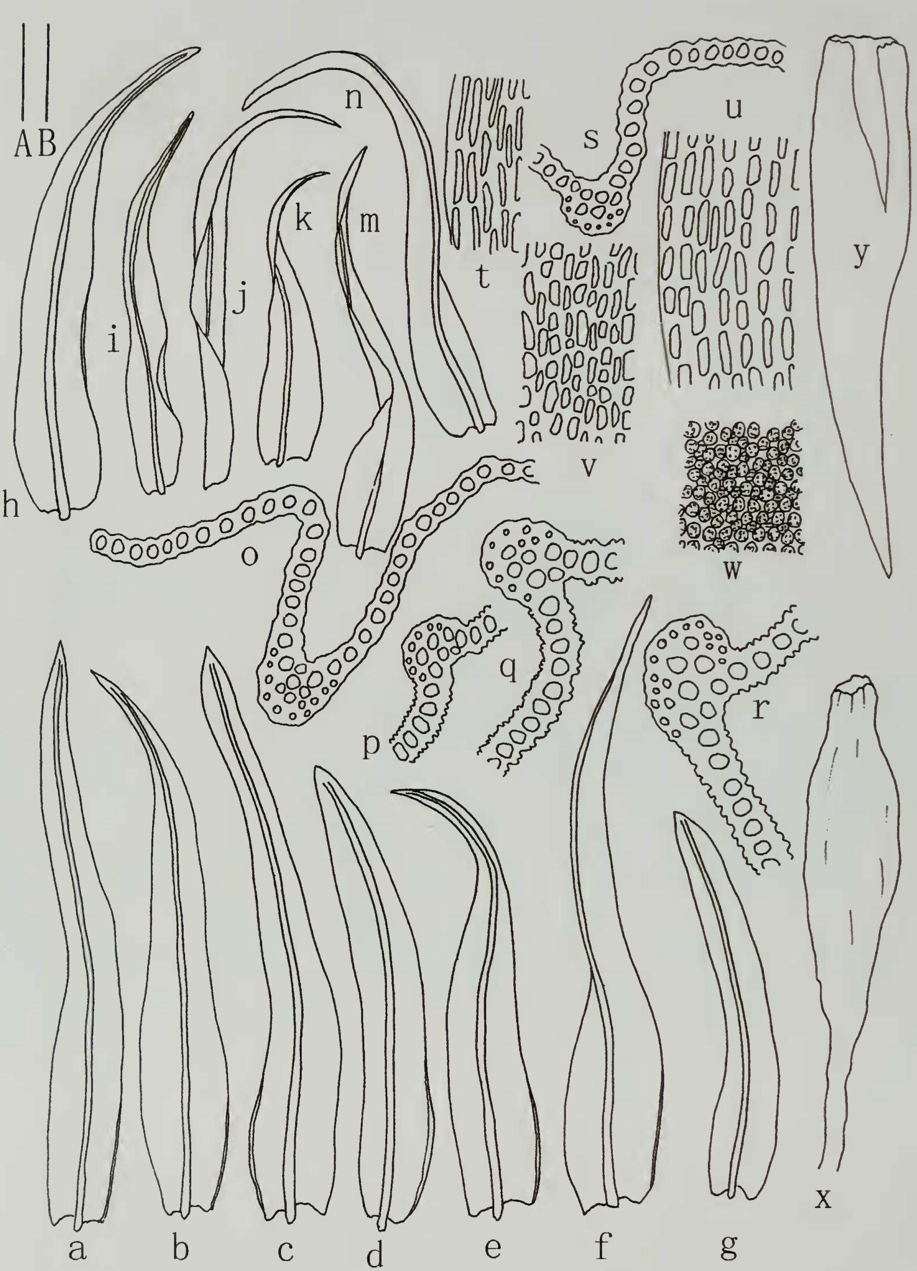


Fig. 9. M. gymnostomum. a-n. **B**ranch leaves; p-r. Upper transverse section of leaf; o,s. Basal transverse section of leaf; t, u. Basal laminal cells near margins; v. Low laminal cells; x. Dry capsule; y. Calyptra. (a-g, o-r, u from holotype of M. brevituberculatum Dix. at BM); (h-n, s-t, v-y from isotype of M. robinsonii at H-BR). Line scales: A = 0.5 mm (a-n, x-y); B = 50 µm (o-w).

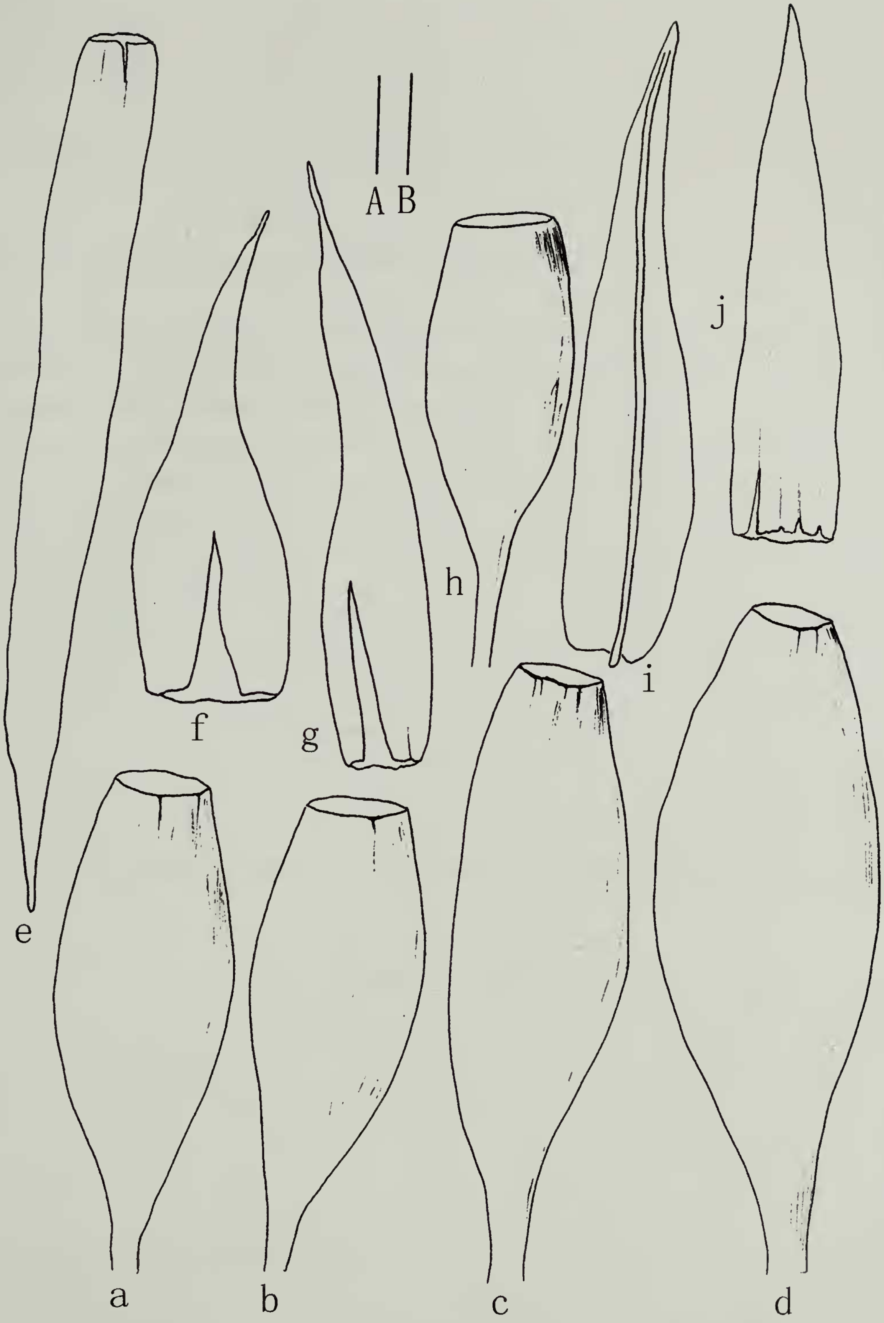


Fig. 10. *M. gymnostomum*. a-d, h. Wet capsules; e-g, j. Calyptrae in different stages; i. Perichaetial leaf. (a from isolectotype of *M. gymnostomum* at NY; b-c, e from Japan, Ferriei, marked as "*M. subgymnostomum* Ther."; f-i from isotype of *M. robinsonii* at H-BR; j from holotype of *M. brevituberculatum* Dix. at BM). Line scales: A = 0.50 mm (a-h, j); B = 0.2 mm (j).

collection by Youngsaye from Taimoshan, Hong Kong, and *M. robinsonii* by R.S. Williams in 1914 based on the material from the Upper Lamao River in the Philippine (in memory of C.B. Robinson who lost his life on a collecting trip). Our check of their types showed that these three species belong to the same taxon, therefore we treated *M. brevituberculatum* and *M. robinsonii* as two new synonyms of *M. gymnostomum.*

Macromitrium gymnostomum was described by Noguchi in details in 1967. The morphological characters of *M. gymnostomum* are relatively stable. Most specimens of this species are characterized by their lanceolate, linear-lanceolate or oblong-lanceolate branch leaves with acute or acuminate apices, usually 1–2.5 × 0.15–0.2 mm. There is a specimen in H-BR collected from Hong Kong, China, marked as "*Macromitrium gymnostomumoides* Broth. sp. nov." (HB2541002). This specimen is rather special in having long linear branch leaves, up to 3.6 mm long, with long acuminate apices. Another specimen collected from Japan was marked as "*Macromitrium subgymnostomum* Thèr. sp. nov." (HB2541001). It is characterized by short lanceolate branch leaves with obtuse acute apices. We consider that the branch leaves of *M. gymnostomum* can vary from lanceolate with obtuse or acute apices to long linear with long acuminate apices, and so, both specimens fall into the range of leaf variation of *M. gymnostomum*. *M. gymnostomum* is easy to separate from other gymnostomous taxa in Asia by its naked calyptrae.

Distribution: China, Japan, Korea, Philippine, Vietnam (Tan & Iwatsuki, 1993).

Other specimens examined: **CHINA: Taiwan**, collector not clear, *no. M3*; **Fujian**, Mt. Wuyi *Guo S.-L. 030001-030008* (SNUH); Amoy, *Chung* (NY); Hong Kong, Loh Fau Mountain (Lofaushan), *E.D. Merrill 11159*, marked as "*Macromitrium gymnostomoides* Broth., new sp."(H-BR 2541002); **Kwangtung** (Guangdong), Ngok Shing Shan, Sai-lin-shan village, *Y.W. Taam 402A* (H); **Hunan**, Badagongshan, *Enroth 58960* (H); Changsha, Mt. Yuelu, *Enroth 48962* (H); Daweishan. *DAW16*, *Virtanen 61994* (H); Mangshan, *Koponen et al. 51680, 51449, 51411, 50762* (H); Shunhuangshan., *Enroth 70674, 70760* (H); Taoyuandong, *Koponen et al. 55092* (H); Wulingyuan, *Koponen et al. 53352, 52057*, 58525 (H); Yuankou, *Enroth 59595* (H); Yunshan, *Enroth 70130* (H). **Zhejiang**, Hangzhou, Tianmu Mountain, *W.R. Buck 23916* (H). **JAPAN: Kagoshima**, Sumiyo-mura, Island. Amami-ohshima, *K. Saito* (H); **Okamura**, Mt. Maya Settsu, *Shutai 684* (H); Okamura, Mt. Kuishi, Tosa, *Shutai 202* (H); Liou, Kine Sushi, 20 Apr 1898, *Ferrie*, marked as "*Macromitrium subgymnostomum* Ther. sp. nov" (H-BR2541001); **Wakayama**, Syögawa, Shirahama-chö. Nishimuro-gun, *T. Nakajima 1129* (H); Ohara, Yuya, Oto-mura, Nishimuro-gun, *T. Nakajima 1229* (H); **Higo,** Aida, *K. Mayebara 3623* (H); **Kumamoto**, Koonose, *K. Mayebara 430* (H).

Macromitrium taiheizanense Nog., J. Sc. Hiroshima Univ. ser. B(2), Bot. 3: 11. 1. 1936. (Fig. 11)
Type: "Formosa: Mt. Taiheizan (ca 2000m), Prov. Taihoku, Aug 1932 (*A. Noguchi 6548*-type, holotype, NICH 365243!)

Plants robust, yellow-brownish above, dark-brownish below, in mats. **Stems** creeping, branches up to 7–8 mm high, densely covered with reddish rhizoids. **Branch leaves** regularly, strongly and spirally twisted when dry, flexuose-spreading when moist, entire, funiculate, or gradually narrowed to a slender acuminate acumen or subula from a broadly lanceolate to ovate-oblong lower portion, 5–7 mm long, 0.5–0.6 mm wide at base, leaf basal longitudinal plicate; margins entire plane; costae ending in the apex; laminal cells unistratose from top to base; upper and median laminal cells smooth and clear, subquadrate-rounded to rounded-quadrate, 8-10 μm wide; basal laminal cells somewhat sinuous, gradually elongate from lower part to base, thick-walled, 22–50 μm, 3.5-7.5 μm wide, bulging and with a papillae per cell.

Sporophytes lateral on branches. Inner perichaetial leaves ovate-oblong, long-acuminate in upper part, 6–7 mm long, similar to the branch leaves in length. Setae rather short, 1–1.2 mm long. **Capsules** ovate, 1.4–1.5 mm wide, 1.6–1.9 mm long, brown, slightly ribbed under a smooth mouth; peristome absent. **Spores** not seen. **Calyptra** campanulate, with many long, yellowish hairs.

M. taiheizanense is a very distinct species, and could be separated from its allies by its funiculate or linear to linear-lanceolate branch leaves with smooth and clear laminal cells from top to middle.

Distribution: China (Taiwan).

Macromitrium formosae Card., Beih. Bot. Centralbl. 19(2): 104. 8. 1905. (Fig. 12)
Type: "Formosae: Kelung, 1903, *Faurie 181*" (isotype, H3090260!)

Plants medium-sized, forming yellowish-brown mats. **Stems** creeping, with erect branches, branches up to 10 mm high. **Branch leaves** crisped when dry, flexuose-spreading when moist, entire, lanceolate to linear-lanceolate,

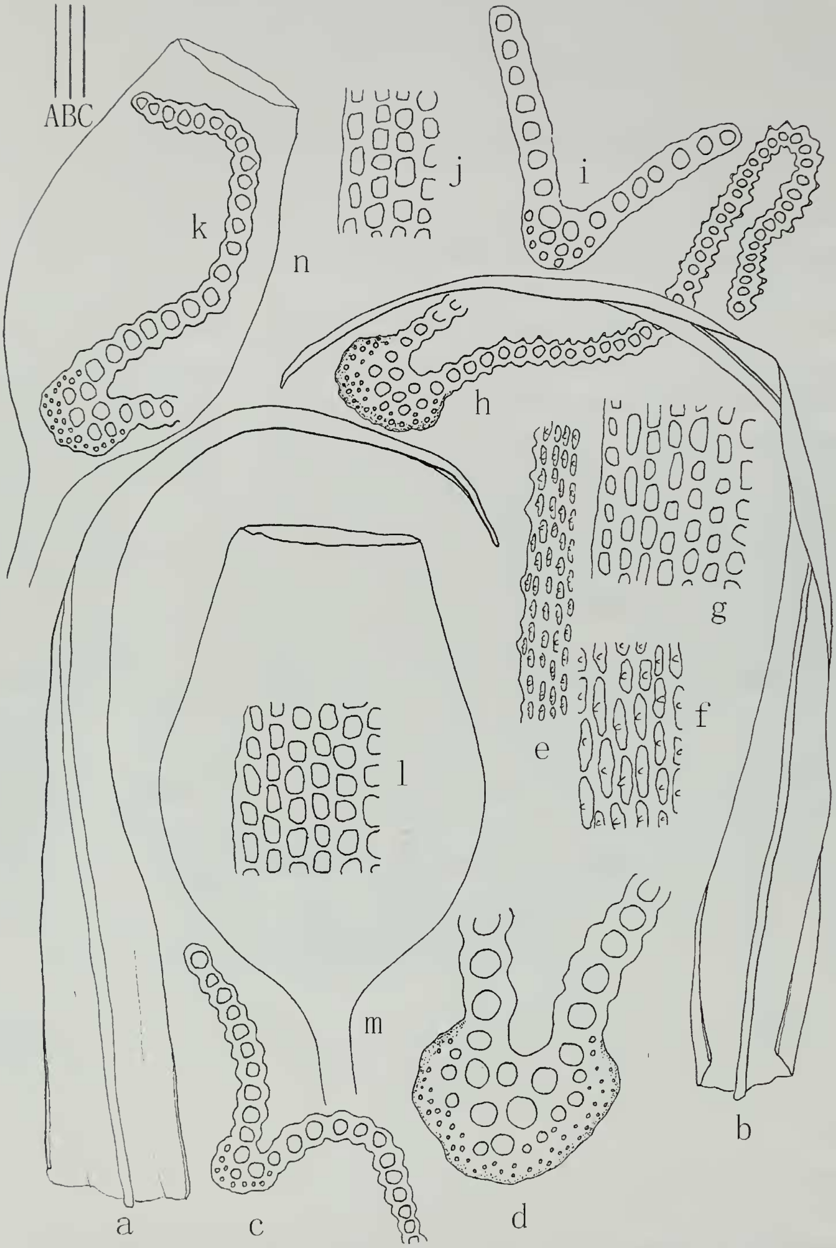


Fig. 11. *M. taiheizanense*. a-b. Branch leaves; c-d, k, i-h. Transverse sections of leaf; e. Lower laminal cells near margin; f. Lower laminal cells; g. Lower laminal cells near margin; j. Upper laminal cells; m-n. Capsules. All from holotype of *M. taiheizanense* at NICH). Line scales: A = 0.5 mm (a-b, m-n); B = 80 μm (c, h, k); C = 50 μm (d, l, f, g, i-j).

acuminate, revolute below on one side, and somewhat plicate at base. 2.3–2.7 mm long, 0.25–0.4 mm wide; costae single, prominent, ending below the apex; laminal cells unistratose from top to base; upper and median laminal cells irregularly quadrate, 7–8 μm wide, rather obscure, densely pluripapillose, basal laminal cells 12–20 μm long, 3–4 μm wide, cell walls sinuous and thick, without papilliae, those along the basal margins regular and smooth. Setae 5–6 mm long, smooth. **Inner perichaetial leaves** similar to branch leaves. **Capsules** ovate, 1.2–1.4 mm long, 0.65–0.8 mm wide, brown, with a small mouth, slightly ribbed below the mouth when dry; peristome absent. **Calyptrae** campanulate, with many long, brown-yellowish hairs.

M. formosae Card. was described by J. Cardot based on the collection of Faurie from Taiwan in 1905. He had compared it with *M. tylostomum* Mitt. even the latter was distinctly different from *M. formosae* by its larger plants, much wider branch leaves with obtuse to subacute apices with a distinct apiculus (Eddy, 1996). In fact, *M. formosae* is somewhat similar to *M. gymnostomum* in appearance, branch leaf shape and laminal cells, but could be separated from the latter by its hairy calyptrae.

Distribution: China (Taiwan), Philippine (Tan & Iwatsuki, 1991)

Macromitrium holomitrioides Nog., J. Sc. Hiroshima Univ. ser. B(2), Bot. 3: 135. 1938.
Type: "Taiwan, Taihoku, Rahau, *Noguchi*" (holotype, HIRO, not seen)

M. holomitrioides Nog., a species recorded from Japan (Kyushu) and China (Taiwan), was described in details by Noguchi (1938, 1967, 1989). Based on Noguchi's descriptions and our check on the non-type specimens, we found that *M. holomitrioides* is similar to *M. schmidii* var. *macroperichaetialium* in their branch leaf shape, capsules constricted or slightly constricted below the mouth in a 4-angled or 4 –furrowed shape, but the former could be separated from the latter by: 1) its broad leaves with large, mammillose or bulging, collenchymatous upper and middle laminal cells; 2) sublinear or subrectangular basal laminal cells without papillae.

Specimens examined: **CHINA:** Hainan island, Jianfengling Mt., *P.C. Chen et al. 789b* (H); ibid, *P.C. Wu W1185016* (H).

Distribution: China, Japan.

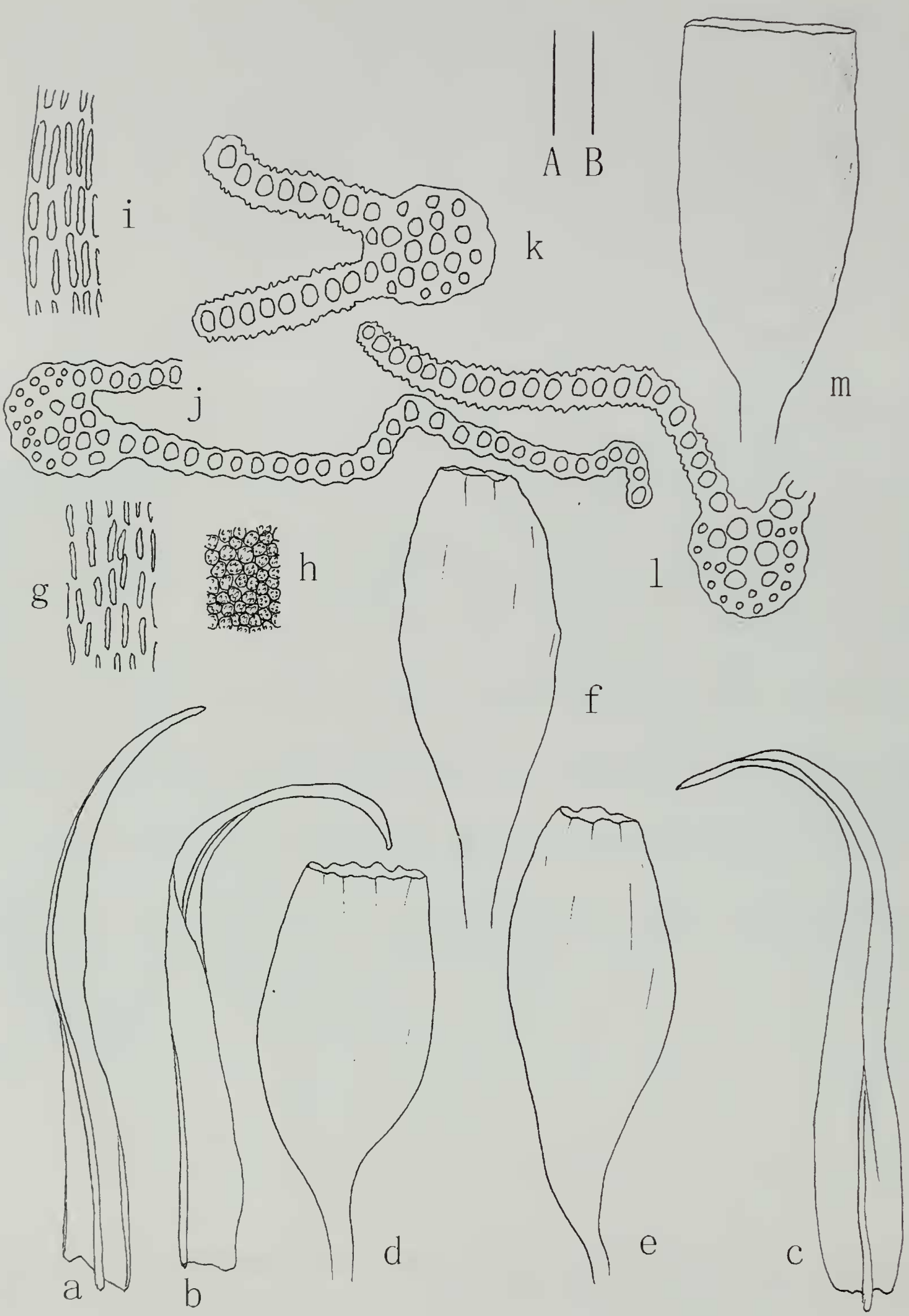


Fig.12. *M. formosae* Card. a-c. Branch leaves; d-f. Dry capsules; m. Wet capsule; g. Basal laminal cells; h. Upper laminal cells; i. Basal laminal cells near margin; j-l. Transverse sections of leaf. All from isotype of *M. formosae* at BH. Line scales: A = 0.5 mm (a-f, m); B = 50 µm (g-l).

Discussion

Taxonomically, the above seven species belong to Sect. *Goniostoma* in the subgenus *Macromitrium*. Based on our checking on the literature and specimens, seven taxa with gymnostomuous capsules of the genus *Macromitirum* in East Asia are confirmed. The main identification characteristics of these seven taxa are the calyptra, shape of branch leaves and inner perichaetial leaves, papillosity of laminal cells and capsule shape. The following key can be applied to separate the above seven taxa.

1. Calyptrae naked, without hairs.................................. ***M. gymnostomum***
1. Calyptrae hairy.. 2

2. Branch leaves funiculate, or linear to linear-lanceolate, up to 5-7 mm long .... ***M. taiheizanense***
2. Branch leaves lanceolate, shorter than 5 mm long 3

3. Median and upper laminal cells smooth or almost smooth .... ***M. heterodictyon***
3. Median and upper laminal cells pluripapillose, mammillose, bulging or collenchymatous 4

4. Median and upper laminal cells mammillose, hyaline, collenchymatous, basal laminal cells smooth .... ***M. holomitrioides***
4. Median and upper laminal cells pluripapillose, basal laminal cells tuberculate or smooth 5

5. Basal laminal cells without papilla .... ***M. formosae***
5. Basal laminal cells tuberculate or with a high papilla 6

6. Inner perichaetial leaves ovate-oblong with acuminate apex, shorter than branch leaves .... ***M. schmidii***
6. Inner perichaetial leaves long lanceolate with linear acuminate apex, much longer than branch leaves .... ***M. schmidii* var. *macroperichaetialium***

Acknowledgements

This research was supported by the National Nature Science Foundation of China (no. 30570121), and the Scientific Research Foundation for the Returned Overseas Chinese Scholars, State Education Ministry. We also gratefully acknowledge the financial support given by the State Scholarship Fund of China and the Finnish-Chinese Botanical Foundation for the visit of the first author to the University of Helsinki in 2003–2004. Thanks to Gao Chien (Institute of Applied Ecology, Academia Sinica), J. Hyvönen, T. Koponen, Xiao-Lan He, J. Heino, S. Sällinen, T. Ahti, and S. Huttunen at Herbarium of Natural History Museum of the University of Helsinki for their hospitality and help during the present work.

References

Cardot, J. 1905. Mousses de I'ile Formose. Beihefte zum Botanichen Centralblatt **19**: 85–148.

Crosby M., R.R.E. Magill, B. Allen and S. He. 1999. *A Checklist of the Mosses*. Missouri Botanical Garden, St. Louis.

Dixon N.H. 1933. Mosses of Hong Kong, with other Chinese mosses. *The Hong Kong Naturalist Supplement* **2**: 1–31.

Eddy, A. 1996. *Splachnobryaceae to Leptostomataceae. A Handbook of Malesian Mosses*, **3**. British Musuem Natural History, [iv] + 277 pp.

Gangulee, H. C. 1976. *Mosses of Eastern India and Adjacent Regions*. Fascicle 5. Calcutta. 1135–1462 pp.

Mueller C. 1853. Musci Neilgherrenses. *Botanische Zeitung* **4**: 58–64.

Noguchi A. 1936. Contributions to the moss flora of Formosa 5. *Transactions of the Natural History Society of Formosa* **26**: 139–147.

Noguchi A. 1938. Studies on the Japanese Mosses of the Orders Isobryales and Hookeriales III. Journal of Science of the Hiroshima University **3**: 135–146.

Noguchi A. 1967. Musci Japonici. VII. The genus *Macromitrium*. *Journal of Hattori Botanical Laboratory* **30**: 207–230.

Noguchi, A. 1972. Mosses of Thailand. *Lindbergia* **1**: 169–183.

Noguchi A (supplemented by Z. Iwatsuki). 1989. *An Illustrated Moss Flora of Japan*. Part 3. Hattori Botanical Laboratory, Nichinan, 742 pp.

O'Shea B. J. 2002. Checklist of the mosses of Sri Lanka. *Journal of Hattori Botanical Laboratory* **92**: 125–164.

Redfearn, P. L., Jr., B.C. Tan and S. He. 1996. A newly updated and annotated checklist of Chinese mosses. *Journal of Hattori Botanical Laboratory* **79**: 163–357.

Sullivant W. and Lesquereux L. 1859. Characters of some new Musci collected by Charles Wright in the north pacific exploring expedition, under the command of Captain John Rodgers, U.S.N. *National Proceedings of Academy of Arts & Sciences* **4**: 275–281.

Tan, B. C. and Z. Iwatsuki. 1991. A new annotated Philippine moss checklist. *Harvard Paper in Botan*y **3**: 1–64.

Tan, B. C. and Z. Iwatsuki. 1993. A checklist of Indochinese mosses. *Journal of Hattori Botanical Laboratory* **74**: 325–405.

Vitt, D. H., T. Koponen and D.H. Norris. 1995. Bryophyte flora of the Huon Peninsula, Papua New Guinea. LV. *Desmotheca, Groutiella, Macrocoma* and *Macromitrium* (Orthotrichaceae, Musci). *Acta Botanica Fennica* **154**: 1–94.

Williams R. S. 1914. Philippine Mosses, *Bulletin of the New York Botanical Garden* **8**: 332–377.